I made a sketch of the pattern traced in it; the radial lines branching out from the foot of the iron column, were about a quarter of an inch thick where they emerged from the column, and extended from four to five feet, diminishing to the finest points, and having ramifications and offshoots like the roots or branches of a tree. They appeared to be analogous to the marks sometimes found on the bodies of persons struck by lightning, and roughly described as resembling trees. These traces were not *ridges,* such as might have been produced by the seismic effects of a shock, but *furrows* cleanly cut in the sand, and leaving bare the basement floor below; had the floor not been sanded there would, of course, have been no record left. I noticed that the traces or furrows were much longer and more marked on one side than on the other, owing, perhaps, to non-homogeneity in the transmitting column.

Art. VIII.—*On Recent Improvements in Electric Lighting.*

By R. E. Joseph.

[Read September 9th, 1880.]

I propose this evening to bring under the notice of the Royal Society a brief description of some of the recent improvements that have taken place during the last few years in the employment of electricity as a means of illumination, and, in doing so, I may state that the description of the various machines, and some of the results obtained with them, have been acquired by reference to *Engineer, Engineering,* the *Telegraph,* and other journals, together with a few notes I have received from home, and a little experience in the way of experiments occasionally conducted here. I have divided my paper into three parts; the first treating of the generators of the current, the second of the apparatus or lamps used in connection with the same, and the third describing some of the several systems in use.

The first introduction of the electric light is, of course, to be dated back to seventy-two years ago, or in 1808, when Sir H. Davy first exhibited the light by means of his powerful battery of two thousand pairs of plates. This light was improved in 1810, and from that date to the present time but little improvement may be said to have taken place in the use of the voltaic current as a practical generator of electricity for illuminating purposes. I think any one who has had experience in fitting up and attending to a battery of the requisite size for such a purpose will agree that, to say nothing of the expense of working and maintaining, the trouble of keeping it in order would preclude its becoming available for any other than temporary purposes, such as lectures, &c., or where, perhaps, a small light for photographic use might be required, for which a battery of eight Bichromate cells of an improved construction, in which the solution is kept agitated by a current of air, has recently been introduced, it is said, in a perfectly practical form. Whilst we are not able, therefore, to recognise the ordinary battery as an efficient or practical generator of the current, I may mention that a thermo-electric battery has been introduced by M. Clamond, formed of iron as the positive and antimony and zinc as the negative elements, and that it has been used for lighting a workshop with great success. The size given is about 8 feet high by 3 feet 3 inches diameter; the electro-motive force is given as being equal to 120 Bunsen cells, and giving a light of about 1000 candles; the internal resistance of the battery is stated to be 0·31 Ohms, and it consumes about 22 lbs. of coke per hour. I am unable to give any more information on this matter; but from what we already know relative to thermo-electric batteries, they do not possess the requisite stability for lighting purposes. We may, therefore, pass on at once to the principles by which the necessary amount of current for our purpose can be produced efficiently and economically.

In 1831 Faraday made known the fact that if a helix, or coil of insulated wire, was moved or rotated in front of a permanent magnet, a current of electricity was induced in the coils, and that by suitable arrangements it could be used in the place of an ordinary battery.

Very many magneto machines, as they are called, were constructed of different forms; the ordinary kind used for medical purposes at the present time is but a modification of Faraday's discovery. In 1854 Siemens introduced an improved armature, which gave a considerable increase in the power to the machines which were then constructed. Then came Holmes, Gramme, and many others; and whilst it is true that in 1857 Holmes's machines were used in one or two lighthouses, they did not come up to the necessary standard required for electric lighting.

In 1863 Wilde introduced his machine, which was a considerable advance on all former; in the place of permanent he used electro magnets, which were excited either by a battery or small magneto machine. At this time, also, Ladd and many others made machines of a similar description. In 1866-7 discoveries were announced by Wheatstone, Siemens, and Varley simultaneously that a separate exciter for the electro-magnets was unnecessary, and that it was sufficient to pass the current induced in the armature through the coils of wire surrounding the electro-magnets, which, provided they were made of hard iron, retained a certain amount of magnetism. Each revolution of the armature served to increase this magnetism, until a maximum effect was obtained. Dating from this period, an immense number of machines based on this principle have been constructed, notably the Gramme, Siemens, Brush, Wallace-Farmer, Maxim, Weston, and a host of others, all differing only in minor details, or different methods of constructing the armatures or connections with the commutators. These machines, however, appear to have vastly different degrees of efficiency, the Siemens, Brush, and Gramme being accepted, I think, as giving the best results.

According to experiments formerly made, the maximum effect was obtained by making the resistance of the wires of the machine equal to the resistance of the outside circuit, following the same law as the voltaic battery.

Now, this rule has usually been carried out, but with this disadvantage—if the resistance of the outside circuit happens to fall lower (such as the carbons of the lamp remaining in contact, &c.) the driving engine running at a higher speed a larger amount of current was developed in the coils of the electro-magnets, heating them, and thus tending to destroy their insulation; it was therefore advisable for safety to work with a larger outside resistance, but with its attendant disadvantage of reducing the amount of current the machine was capable of producing.

In a paper recently read by Dr. Siemens before the Royal Society he stated that he had found it better to increase the size of the wire on the armature and to place a considerably greater resistance than usual on the coils, not by the use of finer wire, but by a greater number of turns, and then only allowing a shunted portion of the current from the armature to pass through them. By this means he increased the efficiency of the machine to a considerable extent, that all danger of its becoming heated was avoided, and that any irregularity in the driving engine did not affect the new machine nearly as much as the old. The necessity of keeping the machine cool whilst working has been recognised by all makers as an absolute requirement. Apart from the fact of the liability to injury by this heating, it has been estimated that hitherto half the current developed in any machine was only available for lighting purposes, the other half being wasted in heating the machine and conducting wires. Various mechanical devices have been used to this purpose. In the earlier forms of Dynamo machines a stream of water was kept flowing through the armature axis; in the Brush machine the iron of the armature has grooves cut nearly through it in various places, so as to have an insulating medium of air in various parts; and, later on, in the Weston machine the iron part of the armature is built up of thin plates so as to leave hollow spaces; the axis is also hollow. This permits the air to rush through and pass between the coils of wire, and so tends to keep them from heating.

I have up to this point treated of machines giving a continuous current—that is, of the same polarity.

Whilst continuous currents appear to be the most efficient, they, of course, consume carbon points unequally, the carbon that is connected with the positive pole of the machine being consumed at nearly double the rate of that of the negative. (Latterly Dr. Siemens has stated that the negative carbon only wastes away from the constant heat, and suggests other substances that might be kept cool for the negative pole.)

For burning carbon candles, and for some systems where more than one light is required to be maintained in one circuit, alternate current machines are required. Many forms have lately been introduced, and apparently with great success; the best appear to be the new Gramme, the Lontin, and the Siemens. All these alternate current machines require an exciter for the electro-magnets, consisting usually of a small

Dynamo machine of the ordinary type; and where a number of machines are required at the same spot, one exciter serves for the whole number. Still further improvements have been made by dividing the commutator into different branches, so that by increasing the number of collecting brushes the current may be drawn off in various circuits, each one being quite distinct and capable of maintaining from one to ten lights on each circuit.

We have now to examine the various forms of lamps that have been designed from time to time for use with the generators of the current.

Probably the earliest form may be considered as a stand into which two pencils of carbon or graphite could be fitted and remain insulated from each other.

As the carbons were consumed they were adjusted by hand; very soon mechanical contrivances were introduced to effect this automatically, but it is not too much to say that although very many beautiful pieces of apparatus are in use for this purpose, and considerable ingenuity has been displayed in designing the various forms, much still remains to be done in this direction. For instance, Mr. Preece, on being examined before the Select Committee of the House of Commons, stated, in reply to a question as to the application of the electric light for the use of the General Post Office, "that at that time (1st July, 1879) he had not been able to determine on a suitable form of lamp for their requirements, which were of a special character. For his purpose he required each light equal to 1000-candle power; it must be absolutely steady, so as not to fatigue the eyes of the operators in the Telegraph Department; and that it must remain steady and uniform for at least nineteen hours without requiring any attention whatever. Not any of the lamps he had examined fulfilled all these conditions, but some had especial qualifications. The Serrin gave the requisite amount of light, the Werderman was perfectly steady, and the Wallace-Farmer sufficiently durable. It is, however, over eighteen months since this report was made, and much progress has been made lately in improving and introducing new forms of lamps. It will be unnecessary to take up much of your time by describing or attempting to describe the immense variety of lamps that have been brought forward. It will suffice to mention those that have apparently met with the greatest success for direct lights—that is, a single light supplied by a continuous current machine. The Serrin lamp, which is almost exclusively used with the Gramme machine ; the Siemens, in several forms ; the Brush, Wallace-Farmer, and Crompton—all these lamps are not only arranged to bring the carbons together as they are consumed, but are so constructed as to maintain them always at the same distance apart. Where such lamps are used with alternate current machines, and where more than one lamp is in the same circuit, a shunt of very high resistance has been lately introduced in the outside circuit between the carbons, so arranged with either an electro-magnet or other contrivance as to bring the carbons closer together when the resistance of the electric arc is increased beyond that point for which the shunt has been arranged to work. In this way the length of the arc is maintained much more uniform and steady than by simply trusting to the strength of the current.

A number of lamps have also been introduced in which a light is maintained by incandescence only, notably the Wederman, Reynir, Andrée, &c., the action of all being of a similar nature, namely, that of a very slender pencil of carbon, the point of which is always in direct contact with a carbon or copper button. Of Edison's platinum wire, and carbon lamps, very little may be said. I do not think that any one who had any experience in electric lighting placed much confidence in his proposed plans ; and we now see that Edison has only done the same as others who had experimented in the same direction many years previously—given it up as being impracticable.

The Jablochkoff candles, about which we read so much, appear to have been considerably improved during the last few months. The removal of the insulating medium from between the carbon pencils, and the arrangement of the lamps, enabling the new carbons to be placed automatically in circuit as the old ones are consumed, has caused this system of lighting to be introduced in many places with considerable success. Wilde's lamp is now similar in principle to the Jablochkoff, with the advantage of extra simplicity; and the latest form of this description of lamp is the Jamin. This, according to the inventor, M. Jamin, gives a greater amount of light than any other of similar form; and on its introduction before a number of leading men in Paris lately was spoken of most favourably.

Now, as to the application oi the various systems. Where large open spaces, halls, &c., have to be illuminated, the employment of single lights, fed by separate machines, appears to have been accepted as being the best and most reliable method; for smaller places, or where the lights have to be extended to a considerable distance, the alternate current machines, with either specially contrived lamps or a candle system, have been more successful. It is, however, certain that up to the present time a subdivided light is not nearly as economical as a direct one.

Taking the whole subject into consideration, in what way can we be said to have improved in electric lighting? I think in very many ways. Firstly, we have gained an amount of experience in practical requirements; we are finding out the especial merits of the several systems, and are thus enabled to apply them advantageously and successfully. The generators and the lamps have undoubtedly been lately improved; the carbons also; and the importance of having the last-named of good quality simply means the success or failure of any otherwise good system of lighting. There is very little reason to doubt that in the earlier days many failures occurred through the imperfections in the carbons. No matter how good or efficient the Dynamo machine or the lamp may be, with bad carbons they must naturally work irregularly; and irregularity in any part of the system, from the driving engine downwards, means unsteadiness of the light. The demand for carbons soon led to their improved make, and I believe they are now to be obtained in a nearly as perfect condition as possible.

Another point that cannot be overlooked, and in which considerable improvements have recently been introduced, is in the motors, or engines, with governors of a sensitive form for driving the Dynamo machines with the same regularity under varying conditions of force.

It is a recognised fact that the motor that drives the machine must do so with perfect steadiness, otherwise a flickering light may be obtained. Many failures have occurred in several systems by inattention to this point.

On board two steamers that have lately been in this port two systems of electric lighting were in use. On the "Potosi" Siemens' alternate current machine, with six differential lamps, was used, the Dynamo machine being driven by a Tangye's four and a-half horse-power engine, fitted with large fly-wheel and sensitive governor; the system was described as being perfectly satisfactory.

The "Chimborazo" had one of the direct Gramme machines supplying a number of Andrée incandescent lamps. On inquiry we found that, although the lights were intense they were unsteady, but that when the whole current was directed into a large Crompton lamp it was all that could be desired. The Gramme machine was driven by a Wheelan engine of five horse-power, with a very small fly-wheel and a governor that did not work. We were informed that the engine ran so steadily that this latter circumstance did not interfere with it; but assuming that the Andrée system has been perfect in other places, it would not be difficult to account for any irregularity in the present instance, for with several incandescent lamps in circuit, each giving only a comparatively small light, I can imagine that the slightest variation in the driving power would make itself very apparent in such lamps, although when the current was utilised in a single arc light of large size its fluctuations were not, perhaps, discernible.

Professor Tyndall recently stated that "he did not believe any fresh discovery needed to make the electric light of general application for all large places;" while Sir William Thompson stated that "he believed before long it would be used in every case where a fixed light was required; that there was immense progress in the actual work carried out by the practical men of the day." Sir William Armstrong has an electric lamp in his library, the Dynamo machine being some mile and a-half distant, and driven by a turbine wheel from a large fall of water.

The British Museum is lighted on Siemens' principle by means of four lights of 5000-candle power each, produced by continuous current, and seven lamps of 400-candle power each, supplied by an alternate current machine; another Dynamo machine serves to excite all the electro-magnets. The four single lamps are on the pendulum principle; the other seven are differential, and the lights are maintained for six hours without touching the lamps. The machines are driven by two eight horse-power steam engines, about 200 yards away from the reading-room. Last winter, about ten in the morning, a dense fog arose, and the many visitors in the museum prepared to take their departure, not being able to read longer, when, the authorities being equal to the occasion, the electric light was turned on, and kept so during the whole day, to the great satisfaction of the readers. The lamps in the library are fitted with gilt reflectors, and they are stated to be an improvement on the silvered.

At Blackpool, a small watering-place of the north, the corporation decided on lighting up the promenade and piers for a certain number of weeks each season. The system adopted is Siemens'. There are eight lights of 6000-candle power, all direct lights. Six of these lamps are suspended from poles 60 feet from the ground; the other two lamps are on the Prince of Wales Theatre, midway between the two piers. The eight Dynamo machines are driven by two Robey engines of sixteen horse-power each; the total length lighted is 1800 yards, and it is spoken of as being perfectly successful.

At the Victoria Station of the Metropolitan District Railway the Jablochkoff system is in use. The space illuminated is 300 feet x 50 feet, and 40 feet high; there are two platforms, with spaces 20 feet between. Ten lights are used—five on the down, dividing the space equally; four on the up, in alternate spaces; and one central, over the bridge. The lights are enclosed in 16-inch opal globes. The Gramme machine is 2373 yards distant, and forms part of a circuit of the same machine that supplies ten lights on Waterloo Bridge. The steam engine that maintains it is now driving several machines, supplying altogether eighty lights. At Ludgate Hill a large establishment has just been lighted by thirteen Jablochkoff's candles, supplied by a Gramme machine, driven by a twelve horse-power gas engine.

The Brush machine supplies from one to sixteen lamps in one circuit. At a cotton factory on Rhode Island machines have been in use some time, supplying eighty lamps; and on the introduction of this system of lighting in London lately it appears to have met with marked success. According, however, to trials made with various machines, the Brush did not give as great an efficiency per horse-power as the Gramme; on the other hand, the continuous current Gramme will only supply one light.

At the Hippodrome, Paris, the electric light apparatus is of the most perfect kind; the Gramme system is used, both continuous and alternate current machines, the lamps being the Serrin and Jablochkoff. The motor power consists of two engines of one hundred and twenty horse-power each.

The different systems enumerated possess certain advantages for each purpose; the knowledge acquired as to the best system for any particular purpose must, I think, be considered an important advancement in electric lighting.

Where large open spaces or rooms require lighting, the direct system, as before stated, appears to be the best, and

Siemens' machines have given the greatest amount of efficiency. For subdividing the light, the Jablochkoff system, certainly, has had the greatest success; but the new Siemens machine should be capable of doing quite as much work. At present the Siemens and the Gramme appear to be ahead of any other system, and have, therefore, been adopted most extensively.

I have not in this paper attempted to enter into any details with respect to the economy of any system, or its relative value as compared with ordinary means of illumination.

The results of experiments I shall shortly be engaged in will, I hope, enable me to lay before you some information on this part of the subject.

Art. IX.—*An Improved Ombrograph, or Self-registering Rain-Gauge.*

By R. L. J. Ellery, F.R.S., F.R.A.S.

[Read September 9th, 1880.]

On the 16th May, 1878, I gave a description of a new self-registering rain-gauge that I had devised, which appears at page 2 of Vol. XV. of our *Transactions*, accompanied by a rough diagram of the arrangement. This apparatus has been in use at the Observatory ever since, and, with the exception of an occasional failure of the intermittent syphon by which it empties itself immediately a quarter of an inch of rain has fallen, it has always worked very satisfactorily. It, however, became apparent to me that it was open to considerable improvement in one or two particulars, which I think I have now succeeded in accomplishing. It will be remembered that the instrument referred to consisted of a receiving vase suspended by two well-made steel spiral springs about five inches long and three-quarters of an inch in diameter. Into this vase the rain as collected in the rain-gauge flowed, the springs stretching as the vase descended with the increasing weight of the collected water